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A Percutaneous Technique for Reduction and Internal Fixation of Displaced Intra-Articular Calcaneal Fractures

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Introduction

A retrospective cohort study demonstrated that, in comparison with open reduction and internal fixation through an extensile lateral approach, our percutaneous technique for reduction and internal fixation of displaced intra-articular calcaneal fractures decreases the rate of complications and achieves and maintains extra-articular fracture reductions just as well[1].

The most effective technique to treat displaced intra-articular calcaneal fractures remains controversial. The extensile lateral approach has been popular because it allows most of the fracture fragments to be directly visualized and reduced. However, complications, including wound dehiscence as well as superficial and deep infection, are common[1-3]. Use of less extensive or percutaneous approaches decreases the frequency and severity of these complications, but reducing the fracture without directly visualizing the fracture lines and providing enough fixation to prevent displacement without plates are challenging obstacles to wide adoption of limited surgical approaches[1,4-7]. With the technique described here, the fracture is indirectly reduced with use of fluoroscopy to assess the reduction, and the fracture fragments are fixed with percutaneously applied screws. It was developed by one of the authors (J.L.M.) and has been utilized exclusively in his practice since 1999. We are presenting a detailed description of this surgical technique, performed entirely in a percutaneous manner, from patient positioning to postoperative management.

The described techniques are utilized for all displaced intra-articular calcaneal fractures that are managed surgically. The timing of the surgery is important; with earlier surgery, it is easier to manipulate the fragments indirectly. Surgery within the first seven to ten days is preferred, and after two weeks it becomes increasingly difficult to obtain a satisfactory reduction. In most cases, soft-tissue factors, including the presence of the “wrinkle sign,” are not considered in the determination of surgical timing, but the surgeon must be committed to a percutaneous approach.

The steps of the procedure include:

Step 1: Patient positioning and imaging

Step 2: Fracture reduction

Step 3: Screw fixation

Step 4: Postoperative management

Step 1: Patient Positioning and Imaging

Position the patient correctly to obtain excellent fluoroscopic views, which are key to the procedure.

- Place the patient in the lateral decubitus position on a radiolucent operating table. The well leg is down and anterior relative to the leg requiring the operation; the leg requiring the operation is positioned flat on firm bumps to support a perfect lateral position of the foot (Figs. 1-A, 1-B, and 1-C). The lateral position facilitates acquisition of optimal fluoroscopic images from the c-arm. The surgeon stands posterior to the patient, which facilitates fracture reduction and placement of screws.
- Obtaining excellent fluoroscopic views is an important part of the procedure, and the c-arm/leg/table orientations that optimize these views are confirmed prior to surgical preparation and draping. Position the c-arm at the foot of the bed and at approximately a 45° angle. A lateral image of the foot is readily obtained with the c-arm in the vertical position (Fig. 1-A).
- The lateral oblique view shows the subtalar joint. Obtain this image by rolling the c-arm

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back approximately 30° and canting it slightly toward the foot of the bed (Fig. 1-B). Various amounts of rotation and canting provide different views of the posterior facet of the subtalar joint. The 45° angle of the c-arm at the foot of the bed facilitates the Harris view of the calcaneus, which is obtained by rotating the c-arm underneath the corner of the table and dorsiflexing the foot (Fig. 1-C). Moving the c-arm allows these views to be obtained without manipulating the foot and leg, which is important when fragments are being provisionally held in reduced positions.

Step 2: Fracture Reduction

The techniques for reducing and fixing joint depression and tongue-type calcaneal fractures differ and will be described separately.

Joint Depression Fractures

- Reduce the tuberosity as the first step in the procedure. The facet will not reduce until the tuberosity is moved out of an obstructing position. Manipulate the tuberosity fragment using a large corkscrew (7 to 8 mm in diameter) placed from lateral to medial in the tuberosity. The starting point should be posterior in the tuberosity and midway from top to bottom. A Harris view shows the depth of insertion (Figs. 2-A and 2-B). Retighten the corkscrew periodically throughout the operation by advancing it another turn.
- Use the corkscrew to move the tuberosity to gain length, achieve inferior and medial translation, and correct varus as judged on the lateral and Harris views. Apply manual traction on a laparotomy sponge around the base of the corkscrew while the surgeon stabilizes it from the top to facilitate longitudinal and inferior distraction of the tuberosity while the ankle is held in plantar flexion (Fig. 2-C). A stack of folded towels under the medial malleolus combined with a medial push on the handle of the corkscrew corrects lateral displacement. Correct the varus deformity by tilting the handle while observing the tuberosity-sustentaculum-medial wall alignment on the Harris view. In difficult cases, insert a Cobb elevator from a small incision laterally and push the Cobb elevator through the fractured midbody of the calcaneus to hook the spike of the sustentaculum medially. Translate the tuberosity and gain length while manipulating the corkscrew, with downward and posterior pressure on the Cobb elevator.
- In some cases, if the facet fragment is large, it may partially block the tuberosity reduction and the two fragments must be sequentially manipulated to achieve final reduction of the tuberosity. Once the tuberosity is reduced, as judged on both the Harris and the lateral c-arm views, achieve temporary fixation from the posterolateral aspect of the tuberosity into the medial sustentaculum with 1.6-mm Kirschner wires. Place the wires somewhat medial as seen on the Harris view to avoid blocking subsequent reduction of the facet fragment(s). Assess the paths of these wires carefully on the fluoroscopic views. Use at least three, and as many as five, wires to maintain the tuberosity reduction position.
- Assess the position and reduction of the articular facet fragment(s) on the lateral and lateral oblique fluoroscopic views, which best profile the subtalar joint. Reduce the fragment with a small instrument (preferably a curved hemostat) inserted through a stab incision directly under the rotated facet fragment (Figs. 3-A and 3-B). If the tuberosity has been correctly repositioned, the facet fragment(s) should fit well beneath the talar articular surface and the intact sustentaculum medially. Once the reduction of the fragment(s) is optimized, perform temporary fixation with 0.45-mm Kirschner wire(s) placed from lateral to medial beginning just posterior and inferior to the fibula from the reduced facet fragment into the sustentaculum. These wires typically incline slightly inferiorly and anteriorly from straight medial to lateral, and their position is assessed on lateral oblique views of the subtalar joint.

Tongue-Type Fractures

- Place two threaded 3 to 4-mm Steinmann pins parallel to each other into the facet (tongue) fragment from posterior (adjacent to the Achilles insertion) toward the anterior margin of the fragment in line with the deformity (Fig. 4-A). On the Harris view, the pins should be aligned with the central body of the calcaneus, parallel, and spread by 2 to 3 cm (Fig. 4-B).
- Use the Steinmann pins to reduce the fragment by employing downward pressure, correcting the varus deformity and pushing the fragment firmly against the corresponding articular surface of the talus. A small instrument such as a hemostat placed under the anterior portion of the fragment may facilitate the reduction. Accurately reducing the facet will also reduce the relatively small tuberosity fragment so that it does not need to be manipulated separately. In very large tongue-type fractures

where there is little anterior calcaneal bone into which to place the pins, Steinmann pins inserted into the talus may be necessary to hold the reduction; they may be left in place for three to four weeks in tongue-type fractures with severe displacement.

Step 3: Screw Fixation

Identify screw entry points and paths using fluoroscopic images, and confirm the final positions with c-arm imaging.

- After the fracture is seen to be reduced on the three c-arm views, internally fix the fracture with percutaneously placed 3.5 and 4.0-mm screws. The Kirschner wire positions relative to the fracture lines can help you to plan and ultimately locate the screw paths.
- Fix the facet fragment, usually by first using two 4.0-mm partially threaded screws. Do not use cannulated screws. The tactile feedback of the 2.5-mm drill, particularly on entry into the sustentaculum, is an important part of ensuring good screw purchase on the medial side. The typical lengths of these screws are 35 to 45 mm. Place them under the joint laterally through the facet fragment and into the sustentaculum. Use the lateral fluoroscopic image to identify the screw entry point, the lateral oblique view to direct the screw toward the sustentaculum, and the Harris view to assess screw length (Fig. 3-C).
- Fix the tuberosity with a minimum of two, and often as many as four, fully threaded 3.5-mm screws. Start these screws posterolaterally in the tuberosity and incline them medially as seen on the Harris view and often slightly superiorly as seen on the lateral view. These screws need to fix into the sustentaculum and anterior process of the calcaneus. It is important to assess the path of these screws on all of the fluoroscopic views, but determine the length of the screws on the lateral view. These screws are typically between 65 and 85 mm in length and are placed using a power driver. Be sure to place these screws solidly against the back of the tuberosity to avoid prominent screw heads when swelling subsides.
- Obtain additional fixation with two or three inferiorly directed 4.0-mm cancellous screws placed from the tongue fragment and proceeding inferiorly into the posterior aspect of the tuberosity.
- Confirm the final screw positions with c-arm imaging, assessing all of the described views for screw length and position.

Step 4: Postoperative Management

Apply a splint; then obtain postoperative images to confirm fracture reduction and screw placement.

- Place the lower leg into a standard splint with the ankle in neutral alignment for joint depression injuries and in 20° of plantar flexion for tongue-type injuries.
- Obtain postoperative radiographs and computed tomography (CT) scans to confirm the fracture reduction and screw placement.
- Remove the sutures at the two-week postoperative visit. At that time, transition the patient to a removable cast boot, with instructions to begin active ankle and subtalar range-of-motion exercises. In some cases, a short leg cast is used for four to six weeks depending on your impression of the quality of the fixation. Typically, eight weeks of non-weight-bearing is advised.

Results & Preop./Postop. Images

The results of percutaneous reduction of displaced intra-articular calcaneal fractures in seventy-nine patients with a total of eighty-three fractures were compared with those obtained by another surgeon using the extensile lateral approach[1]. There were no significant differences in the degree to which the Böhler angle was restored ($p = 0.31$) or in the average loss of postoperative reduction at the time of fracture union. There were significant differences in the rates of complications. None of the patients who underwent percutaneous reduction and internal fixation developed a deep infection.

What to Watch For

Indications

- Displaced intra-articular calcaneal fractures
- Displaced extra-articular calcaneal fractures

Contraindications

- Calcaneal fractures more than three weeks old
- Lack of adequate fluoroscopic imaging
- Patient's inability to adhere to weight-bearing restrictions after surgery
- Patient electing nonoperative treatment

Pitfalls & Challenges

- Attempted reduction of fractures more than three weeks old
- Prominent screw heads in the tuberosity
- Screws protruding through the inferior aspect of sustentaculum (irritation of the flexor hallucis longus tendon) or into articular surfaces
- Failure to achieve good screw fixation in the anterior and medial aspects of the calcaneus
- Premature weight-bearing, especially after tongue-type fractures

Clinical Comments

- Can adequate reduction be obtained and maintained with use of percutaneous reduction techniques with the fracture fixed with screws alone?
- Should postoperative CT scans be utilized to assess articular reductions in all cases?
- Can severely comminuted articular fractures (Sanders type IV) be treated with percutaneous techniques?
- How difficult is the learning curve for the use of percutaneous techniques?

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Fig. 1-A: A lateral fluoroscopic image is obtained with the c-arm positioned at an approximately 45° angle from the anterior foot of the bed.

Fig. 1-B: The c-arm is rotated back and canted toward the foot of the bed to obtain a lateral oblique view.

Fig. 1-C: The Harris view of the calcaneus is obtained by rotating the c-arm underneath the corner of the table and dorsiflexing the foot.

Fig. 2-A: The corkscrew is placed from lateral to medial, just engaging the medial cortex as seen on the Harris image. Also note that the position is posteroinferior to the posterior facet.

Fig. 2-B: The corkscrew is placed from lateral to medial, just engaging the medial cortex as seen on the Harris image. Also note that the position is posteroinferior to the posterior facet.

Fig. 2-C: Distraction with use of a laparotomy sponge around the base of the corkscrew facilitates restoration of length, medializing and correcting varus malalignment of the tuberosity. The arrows indicate forces applied by the surgeon.

Fig. 3-A: Lateral oblique fluoroscopic view showing the reduction maneuver. The black arrow indicates the sustentacular part of the posterior facet, and the white arrow indicates the lateral part of the posterior facet.

Fig. 3-B: Lateral oblique fluoroscopic view showing the reduction maneuver. The black arrow indicates the sustentacular part of the posterior facet, and the white arrow indicates the lateral part of the posterior facet.

Fig. 3-C: Lateral oblique fluoroscopic view showing provisional Kirschner wire fixation of the reduction with the first screw just under the lateral joint line.

Fig. 4-A: Clinical photographs showing Steinmann pin manipulation of the tongue fragment.

Fig. 4-B: Fluoroscopic views demonstrating Steinmann pin fixation in the tongue fragment and manipulation to achieve reduction.

Fig. 1-A

Fig. 1-B

Fig. 1-C

Fig. 2-A

Fig. 2-B

Fig. 2-C

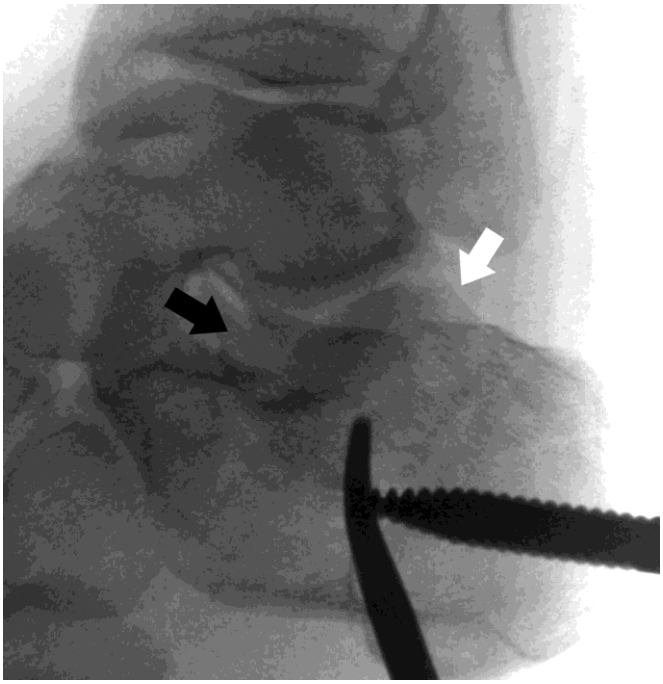

Fig. 3-A

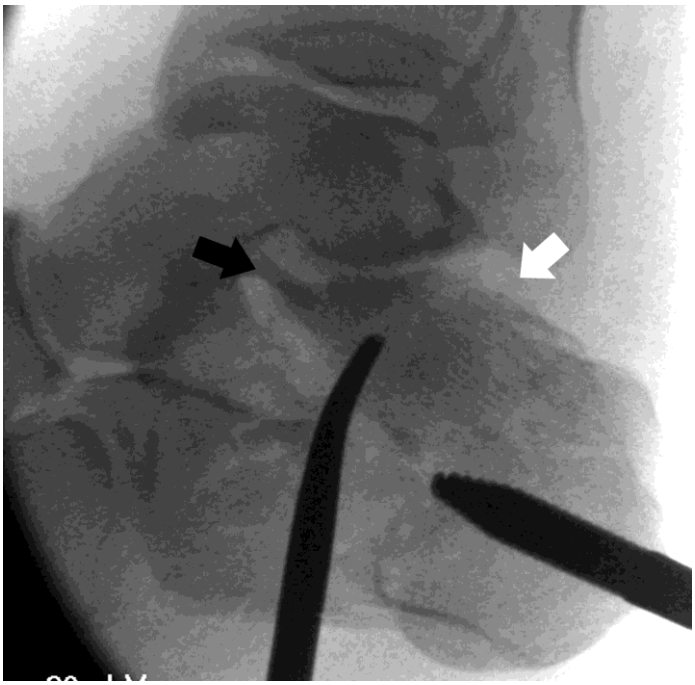

Fig. 3-B

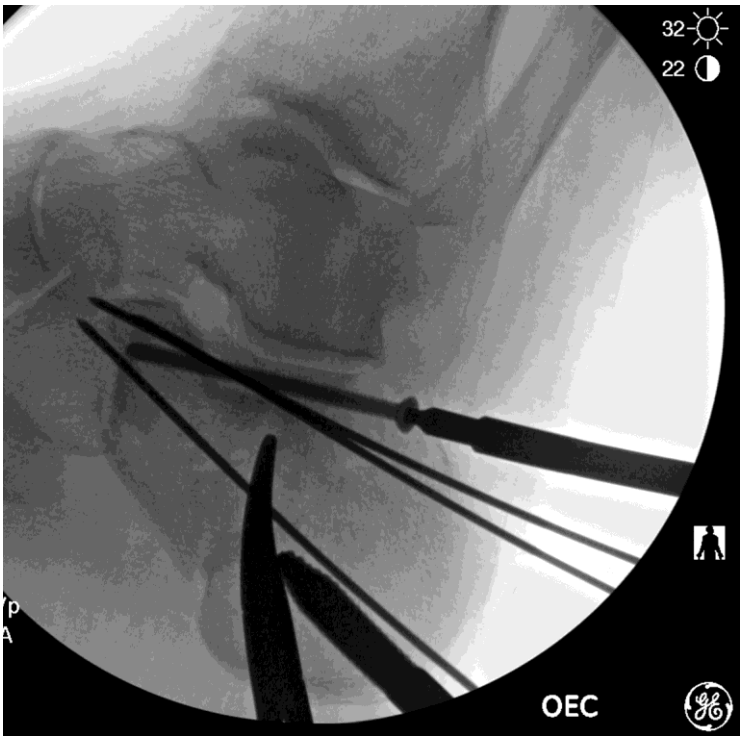

Fig. 3-C

Fig. 4-A

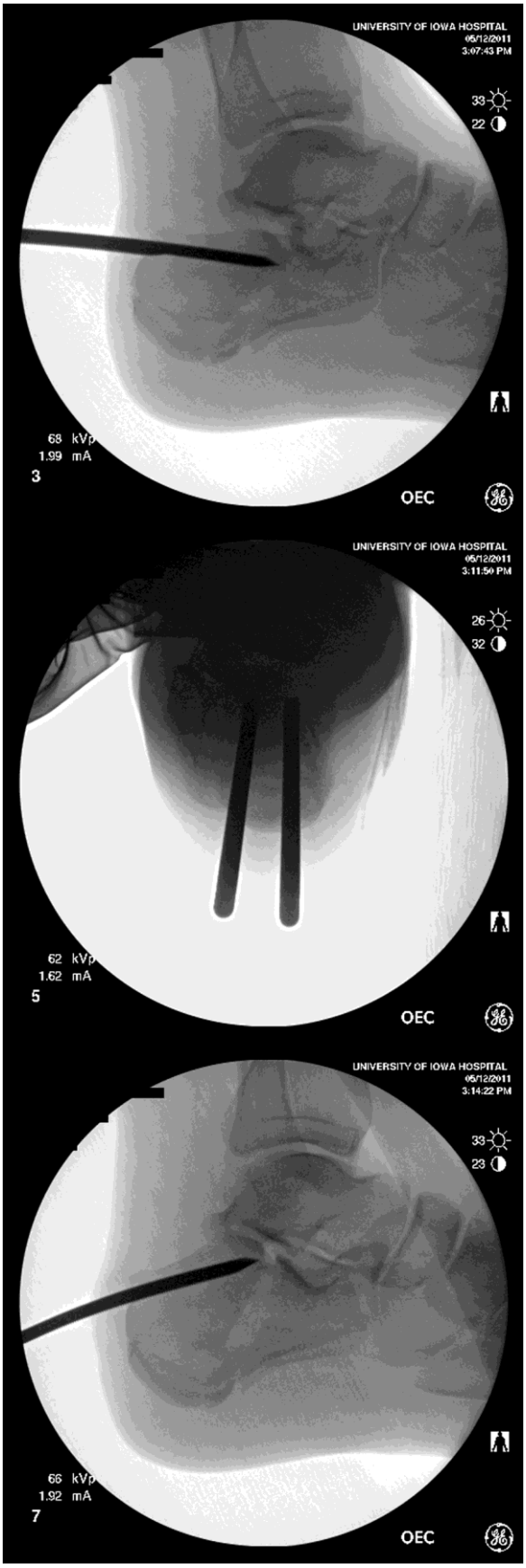
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Fig. 4-B